Assessment of Effects of Mixed Phase Icing Conditions on Thermal Ice Protection Systems

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Abstract

Aircraft flying at subsonic speeds through clouds below 8000 meters (approximately 26,000 ft) can be subject to ice formation on critical aerodynamic surfaces. Typically, ice accretion results from small super-cooled droplets (droplets cooled below freezing), usually 5 to 50 microns in diameter, which can freeze upon impact with the aircraft surface. The global atmospheric environment is characterized by a wide range of icing conditions which vary in extent and in intensity. For the purpose of aircraft icing certification the icing conditions defined in Appendix C of Federal Aviation Regulation (FAR) Part 25 are used. These icing conditions also guide the design and certification of ice protection systems which are employed to protect aircraft aerodynamic surfaces from the adverse effects of ice accretions.

A range of ice protection systems has been developed over the years. In general, ice protection systems use mechanical means for ice removal and/or thermal means for ice prevention. Energy requirements for thermal systems are based on the liquid water levels defined in the icing certification envelope. In intense icing conditions the performance of thermal protection systems is significantly degraded due to the increased water loading, and the safety of the aircraft is compromised.

Aircraft encounters with intense icing conditions outside the icing certification envelope have increased recently as a result of the greater number of aircraft in the commercial airline fleets and the increased utility of these aircraft. In many cases, aircraft have been exposed to icing clouds containing super-cooled large droplets (SLD), freezing drizzle and freezing rain as well as mixed phase icing conditions involving super-cooled droplets and ice crystals.

This research program is a two-year experimental research effort to investigate the impact of mixed phase conditions on thermal ice protection systems. This is in direct response to the FAA Icing Plan Task 13C which states that the FAA will assess "the safety threat that is posed by mixed-phase conditions".

Tests will be conducted in a small icing tunnel facility with a NACA 0012 airfoil which has been instrumented with electrical heaters and thermocouples for measuring the power input to the thermal ice protection system. The experimental data will include system performance measurements for a range of icing conditions including mixed phase (water and ice) cases. In addition to the experimental measurements, visualization studies will be performed with advanced imaging systems to study the interaction of the ice and liquid particles with the cold and heated wing surface.

Research findings will be compiled in a final report which will be submitted to the FAA at the end of this two-year research program.